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Seasoning ingredient variety, but not quality, is associated with greater intake of beans and rice among urban Costa Rican adults

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List of Abbreviations

BMI; Body Mass Index

T; Tertile

ABSTRACT

Exposure to a variety of flavors may promote food enjoyment, but few studies have examined the relationship between food seasoning and food intake. We hypothesized that using a higher variety (number) of eleven seasonings to prepare two staple foods (beans, white rice) would be associated with intake of those foods in a population-based case-control study of Costa Rican adults in urban vs. rural areas (n=1,025), where cooking and dietary practices differ. Participants were surveyed about the variety of seasoning ingredients added when preparing beans or rice. Ingredients were also categorized by their dietary quality (healthfulness), and scores for seasoning variety and quality were created. Multivariable linear regression was used to determine the association between variety and quality scores (continuously and in tertiles (T)) and intake of each staple food. Seasoning variety was positively associated with daily servings of beans (β=0.02, p=0.01; 1.31 and 1.23 servings/day in T2 and T3 versus 1.02 servings/day in T1, p<0.05) and rice (β=0.04, p=0.005) in the urban areas only. No differences in ingredient quality across increasing intakes of beans or rice were noted, and the joint associations between variety and quality were not significant. In conclusion, a greater variety, but not quality, of seasoning ingredients was positively associated with intakes of beans and rice in urban Costa Rican adults. Our results suggest that increasing the variety of seasonings added to beans may be a culturally-appropriate strategy to improve intake of this healthy staple food among urban Costa Rican adults.

Keywords: variety and diet quality; seasoning; bean and rice intake; Hispanic and Latino health; case-control

1. INTRODUCTION

White rice and beans are staple foods in many Latin American countries [1]. Among Costa Rican adults, white rice (herein referred to as rice throughout) and beans represent the primary sources of energy and protein intake respectively [2-4]. Between 1995 and 1999, Costa Rica experienced the second highest growth rate (12%) in rice consumption among countries with similarly high rice intake [5], while bean intake has decreased by 46% over the last 30 years [6, 7]. Rapid urbanization has exacerbated the reduction in bean intake in some areas of Costa Rica potentially due to higher incomes and greater availability of processed foods, while rural residents have tended to maintain more traditional cooking and dietary practices [3, 4]. Therefore, strategies to improve dietary quality in urban regions of Costa Rica are especially warranted.

Excessive rice intake, a food with putative unfavorable metabolic effects [8-10], is concerning given the global rise in obesity-related chronic diseases [11], including in Costa Rica [12-14]. The concomitant reduction in bean intake is noteworthy because beans are nutrient-dense, affordable sources of both protein and fiber and have been previously shown to be associated with lower levels of cardiometabolic risk factors [8] and incidence of myocardial infarction [13] in Costa Ricans. Despite awareness of the adverse health consequences of excess rice and reduced bean intake, expressed preferences for how these foods should taste has made it challenging for Costa Rican adults to improve dietary quality by interchanging the level of intake of these staple foods [7]. Thus, it is important to consider alternative methods to improve diet

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quality in this population. As such, intervention strategies that promote bean intake and reduce rice intake have the potential to improve cardiometabolic health in this population.

One strategy targeting food choice that may be easy for individuals to implement is to increase variety within healthful, less energy-dense foods. Food variety has been shown to increase food intake within and across meals [15], and it may be possible to harness this preference to increase consumption of healthier foods. The "variety effect" is robust at the food level, but researchers have only recently started exploring whether increasing the perception of variety [16, 17] and enhancing sensory variety (e.g. variety in color, shape, texture, and flavor or seasoning) can influence intake [18-21]. Research has also found that using herbs and spices to enhance the flavor of healthful foods can increase intake [22, 23], which may be an applicable strategy to improve diet quality in diverse populations.

However, it remains unknown whether greater seasoning variety is associated with the intake of staple Costa Rican foods (i.e. beans and rice), and if the dietary practices in urban versus rural areas influence those associations. Similarly, researchers have not examined whether the dietary quality of staple foods is maintained or improved with greater sensory variety. Finally, research in population studies is limited because few studies measure variables related to sensory variety.

Therefore, using unique data from urban and rural Costa Rican adults, our primary research objective was to examine whether greater seasoning variety used in the preparation of beans or rice was associated with intake of these foods, with the hypothesis that seasoning variety would be positively associated with intakes of beans and rice. Additionally, because dietary variety is not always associated with dietary quality [24, 25], in exploratory analyses, we examined the associations between ingredient quality and intake as well as the joint associations of variety and quality on bean and rice intake. In order to examine our research objectives, we analyzed secondary data from a population-based case-control study of Costa Rican adults that collected unique detailed information about the seasonings used to prepare beans or rice, as well as a validated assessment of intake of these staple foods. This research enhances our understanding of how culturally-accepted food preparation practices influence the intake of staple foods. Ultimately, such knowledge advances human nutrition by identifying dietary targets for interventions that could help mitigate the adverse health effects driven by the nutrition transition in Costa Rica [14].

2. METHODS AND MATERIALS

2.1: Study Population:

Participants were a subset of cases and controls who took part in a population-based study of heart disease in Costa Rica between 1994 and 2004. Detailed descriptions of study methodology

have been previously published [3, 26]. Cases were identified as survivors of a first acute

myocardial infarction; control participants were randomly selected from the National Census and

Statistics Bureau of Costa Rica and matched for age, sex, and area of residence at the county-

level with cases. Control participants were excluded if they had a history of myocardial

infarction or if their physical or mental status precluded participation.

For this analysis, we used data from a subset of 1,025 out of 1,062 participants who responded to

questions about the ingredients they used to prepare beans and rice. The subset represented

approximately 23% of the full sample (n=4,540) (**Supplemental Figure 1**) [13].

This study was conducted according to the guidelines in the Declaration of Helsinki and the

Human Subjects Committee of Harvard T.H. Chan School of Public Health and the University of

Costa Rica approved all human subject procedures.

2.2 Dietary Assessment:

Diet was measured using a validated, country-specific semi-quantitative food frequency

questionnaire [27]. Bean and rice intake were assessed by asking participants to specify the

portion size and frequency with which they consumed each food over the previous year.

Frequency categories ranged from <1 serving/month or never to ≥6 servings/day; one serving of cooked beans corresponded to 1/3 cup and one serving of cooked rice corresponded to 2/3 cup. Mixed rice and bean dishes did not contribute substantively to intake of either food (median intake: 1 serving/wk) [8] and were excluded from the present analysis.

Participants were first asked whether they cooked rice and beans (affirmative for 98.7% and 95.7% of those asked, respectively). If so, the primary person in the household preparing the foods responded to open-ended questions about the recipes. Ingredient amounts for rice, beans, salt, solid fat, and oil were directly weighed or measured and fieldworkers visually confirmed the type of oil used for cooking. Participants were then asked whether they added eight ingredients typically used in Costa Rican cuisine. For beans, these ingredients were onion, garlic, cilantro, celery, sweet pepper, bouillon cube, oregano, and English/Worcestershire sauce. For rice, the ingredients were onion, garlic, cilantro, celery, sweet pepper, bouillon cube, carrots, and *achiote* (annatto).

2.2.1 Variety Assessment:

The eight common ingredients added to beans or rice were assessed as "no", "sometimes," and "yes", which were assigned 0, 1, and 2 points, respectively. Because frequency of use was not queried for salt, oil, or solid fat, participants received a score of 0 if they reported no use of these ingredients; and 2 points for each ingredient they reported adding. We calculated bean recipe

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variety by summing the number of ingredients used to prepare the beans, which included

ingredients from a two-step process of cooking and dressing the beans (maximum possible

score=44, maximum observed score=32). If a participant did not dress the beans (53%), we used

only their bean recipe score. Rice recipe variety was the sum of ingredients used in the single

rice-cooking recipe (maximum possible score=22, maximum observed score=19).

2.2.2 Quality Assessment:

We estimated the quality or relative healthfulness of the ingredients used to prepare beans or rice

by allocating 2 points for 'always' adding herbs, spices, or vegetables rated as healthful [28], 1

point for 'sometimes' adding the ingredient, and 0 points for not adding the ingredient, and then

summing the points. Use of English sauce and bouillon cubes, which are high in sodium and thus

considered unhealthy [29],were reverse-coded. Because salt and solid fat are unhealthy nutrients

[29, 30], participants received 2 points if they reported no use of these ingredients; 1 point for

using less or equal than the median intake per cup of beans or rice for consumers of that

ingredient; and 0 points for using more than the median intake.

Oil intake was scored by type, according to its fatty acid profile as well as nutritional and health-

promoting properties [31-33]. Not adding any oil was assigned 0 points; adding sunflower or

corn oil was assigned 2 points for less or equal than the median intake and 1 point for adding

more than the median intake; adding either olive, soybean, or canola oil, was assigned 1 point for

adding less than or equal to the median or 2 points for adding more than the median; adding palm

oil received 1 point for less than or equal to the median or 0 points for adding more than the

median. The maximum possible quality score was 44 (maximum observed score=32) for bean

recipes and 22 (maximum observed score=16) for rice.

2.3 Covariates:

Trained personnel interviewed participants about sociodemographic and lifestyle characteristics

and physical activity [3, 26]. Each participant's average weight and height were calculated after

being measured in duplicate with light clothing and no shoes, and these values were used to

calculate body mass index (BMI). Participants self-reported the frequency, duration, and

intensity (in metabolic equivalents) that they engaged in various physical activities, and total

physical activity was calculated by summing energy expenditure from each activity. Due to

regional differences in dietary intake observed in previous research, we stratified our sample *a*

priori according to population density into rural and periurban regions (herein referred to as

rural) and urban regions [3, 13, 34, 35].

2.4 Statistical Analyses:

We examined the continuous associations between seasoning variety and seasoning quality and

intake of beans and rice intake. We also divided variety and quality scores for beans and rice into

tertiles (T) and examined intake of beans or rice across variety and quality score tertiles. We had

80% power to detect a significant difference of 0.17 units between groups. We modeled the joint

associations between variety and quality on bean or rice intake, specifying a *p* value of 0.05 *a priori* to detect a significant interaction. We also tested for effect modification by case-control status and sex, specifying a *p* value of 0.05 *a priori* to detect a significant interaction.

The ranges for each tertile of the variety score for beans were 0-7 (T1), 8-11 (T2), and 12-32 (T3) ingredients; the ranges for variety score for rice were 0-8 (T1), 9-10 (T2), and 11-19 (T3) ingredients. The quality score for beans was categorized as: 4-12 (T1), 13-19 (T2), and 10-36 (T3) and the quality score for rice was categorized as 1-7 (T1), 8-9 (T2), and 10-16 (T3). Multivariable linear regression was used to examine the continuous associations between seasoning variety and quality and intake of beans and rice. We also assessed whether the mean intake of beans and rice differed across variety and quality score tertiles using the Tukey multiple comparison test. The base model was adjusted for primary demographic covariates (age, sex, case-control status, area of residence), as well as rice intake for analysis of beans only (Model 1). Further adjustment for recognized socioeconomic and behavioral covariates (income, smoking, physical activity, total energy intake (Model 2), and BMI (Model 3)) were singly added to final models to address potential confounding. We used median splits of the variety and quality scores for beans and rice to examine the joint associations between variety and quality on bean and rice intake. All analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

3. RESULTS

The sample was primarily comprised of male, middle-aged adults from urban neighborhoods
(Table 1). Physical activity levels, energy intakes, intakes of beans and rice, and rice seasoning
variety were higher among participants living in rural vs. urban areas. Conversely, household
income and seasoning quality were either similar or higher among urban vs. rural residents. The
type of seasoning ingredients used also differed by area of residency. In the preparation of
beans, rural residents used more salt and solid fat and fewer vegetables and spices like onion,
oregano, and sweet pepper. Similarly, in the preparation of rice, rural residents used more salt
and solid fat and less oil, but more carrot and cilantro. On average, participants reported variety
scores of nearly 10 for both beans and rice; reported quality scores were nearly 16 for beans
versus nearly 9 for rice.

The mean age and percent of female participants were similar across tertiles of bean and rice
variety and quality scores; however some socio-demographic and dietary characteristics differed
across tertiles of the scores **(Table 2)**. The highest tertile for bean quality and variety had a
higher proportion of urban residents as well as a higher mean income and total energy intake.
Participants with high (T3) versus low (T1) bean variety and bean quality scores used more of
every ingredient in preparing beans. A similar pattern was observed among participants with
high (T3) versus low (T1) rice variety except for the use of solid fat, which was more frequently
used among participants in first tertile. Conversely, participants with high (T3) versus low (T1)

rice quality scores used less solid fat, equivalent amounts of salt, *achiote*, and bullion, and more of every other seasoning ingredient.

3.1 Seasoning ingredient variety and intake of beans and rice: Within the overall population, more seasoning variety was associated with higher bean (β=0.01, p=0.007) and rice (β=0.02, p=0.02) intake in the continuous base models, but these were attenuated and non-significant after further adjustment (**Supplemental Table 1**). Among urban residents, bean intake was significantly higher among individuals in the second and third bean variety tertiles as compared to the first tertile in all models after adjustment for potential covariates (mean bean intake= 1.23 (T3) and 1.31 (T2) vs. 1.02 (T1) servings; p<0.05) (**Figure 1**). This positive association was also significant in the fully-adjusted continuous model (β=0.02, p=0.01). Moreover, greater bean intake was not adversely associated with BMI; individuals consuming greater than or equal to 1 serving versus less than 1 serving/day of beans had significantly lower BMI in multivariable-adjusted analyses (BMI=25.2 vs. 26.6, p=0.0004 in T3 vs. T1). Rice seasoning variety was positively associated with rice intake in all continuous models among urban residents (β=0.04, p<0.01) only. However, no significant differences in rice intake across rice variety tertiles were observed. No associations were observed among rural residents for either food. Additionally, no significant effect modification by case-control status was detected. All models are presented in **Supplemental Table 1**.

3.2 Seasoning ingredient quality and intake of beans and rice: Bean intake was higher among all individuals in the highest versus lowest bean quality tertile in the base model, however, this association did not persist with adjustment for additional covariates. Similarly, among urban adults, bean intake was higher among individuals in the second and third versus first quality score tertile, but this association attenuated with adjustment for BMI. No associations were observed between ingredient quality and rice intake in the overall population or among urban or rural adults. However, cooking rice with more salt was associated with more daily servings of rice (β=0.02, p=0.01). The final multivariable models are presented in **Figure 2,** and all models are presented in **Supplemental Table 2**. No significant joint associations were detected between variety and quality scores for bean or rice intake in any model (data not shown).

4. DISCUSSION

The results from this study among rural and urban areas residents living in the Central Valley of Costa Rica support our hypothesis that greater seasoning variety is associated with greater intake of beans and rice. However, this hypothesis was only supported among those living in urban areas. The quality of the ingredients added was not associated with intake overall, though there was some suggestion, albeit non-significant, that ingredient quality was higher among urban adults with higher bean intakes. Importantly, quality was not compromised as variety increased, which is especially important for public health practitioners who could advocate increasing seasoning variety with healthful ingredients to increase intake of beans, a putative healthy food, when possible. Moreover, our analyses suggested that greater bean intake would not adversely affect BMI.

Manipulating sensory variety by increasing the variety of ingredients used to season healthful foods like beans may be an effective, inexpensive strategy to increase their intake and subsequently improve diet quality and cardiometabolic risk [8]. For example, the inverse association observed between bean intake and BMI in this study suggests that increasing seasoning variety to increase intake of beans among urban Costa Rican adults may favorably affect obesity-related health outcomes. Among US adults, even small improvements in dietary quality are related to a reduced incidence of cardiovascular disease, type 2 diabetes, and cancer [36], and among Costa Rican adults, higher intake of beans has been shown to be associated with a healthy cardiovascular profile [8, 13]. In particular, Mattei et al. [8] found that substituting one serving of beans for one serving of white rice would reduce the risk of metabolic syndrome by 35% in the same population, and meta-analyses suggests that an isocaloric increase of 1 serving per day of beans (typically in place of other dietary carbohydrate or animal protein) would reduce total and LDL cholesterol [37, 38]. Moreover, the potential increase in bean intake (0.25 servings/day) that could be attained by increasing seasoning variety could help move the population closer to the minimum targeted intake of 0.5 cups per day recommended by Costa Rican dietary guidelines [39].

Beans already exist as an inexpensive and established healthful staple food in the Costa Rican diet, and our results suggest that increasing seasoning variety to further increase bean intake would not be cost prohibitive in urban areas, particularly as compared to the cost of other dietary interventions [40, 41]. In our study, individuals in the highest bean quality and variety tertiles

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also had higher incomes and were likely more able to afford healthful seasonings; however, the

positive associations between variety and intake persisted even after adjusting for income,

suggesting that lower income individuals are also able to afford more varied recipes.   In

particular, we found no association between income and bean recipe variety or quality among

urban participants (data not shown). Greater variety among vegetables has been shown to

increase intake and improve dietary quality among lower income groups [42], and the present

study suggests that expanding seasoning variety may produce similar effects. In areas where

limited access to healthful food diversity contributes to inadequate intake of healthful foods [43],

manipulating sensory variety holds promise as a novel strategy to improve diet quality.

Notably, significant results were observed in urban, but not rural Costa Rican residents. This

may be related to differences in ingredient availability, variable adherence to traditional and

familiar regional recipes, or differences in dietary or other related lifestyle behaviors. [3, 4]. The

observations among urban residents is particularly important because in Latin American

countries, including Costa Rica, greater urbanization has been associated with reduced intake of

healthful staple foods such as beans [4, 13], in part due to greater availability of inexpensive,

palatable, energy-dense foods [4, 44]. However, our results suggest that it may be possible to

combat the effect of urbanization on food choice by making staple foods such as beans more

palatable. Moreover, increasing the variety of herbs and spices used to season beans may be

particularly effective because it cost-effectively enhances perceived variety and subsequently,

palatability, potentially even when less healthful ingredients like solid fat and sodium are

reduced [22, 23, 45]. Substituting herbs, spices, and oils – such as soybean oil - for salt and solid

fat may help improve the health profile of rice in this population, as cooking rice with more salt was associated with more daily servings of rice.

Importantly, the strategy of using greater seasoning variety to increase bean intake may help people subtly improve their diets while maintaining traditional dietary patterns. Food neophobia can make it challenging to increase intake of healthier foods whereas manipulating the flavor of a familiar staple food may help address this barrier [45]. Further, by gradually altering accepted flavors through repeated exposure to new recipes, it may be possible to expedite the liking and acceptance of different preparations of healthy, staple foods [23, 45]. One particularly notable finding was that existing quality and variety of ingredients used to season beans was already relatively high, suggesting that the Costa Rican tradition of using variety in seasonings may facilitate the introduction of novel ingredients in the preparation of staple foods.

A recent qualitative study of Costa Rican adults examined the barriers and motivators associated with increasing intake of beans and found that sensory properties are an important determinant of food choice [7]. In particular, adults reported that beans were less versatile to prepare than rice, suggesting that monotony associated with bean consumption may contribute to reduced intake over time. Participants also indicated that, while motivated to improve their diet, it would be challenging to simply increase the ratio of beans to rice because it would reduce the pleasure associated with eating; thus, recommendations to increase seasoning variety to make eating beans more enjoyable may be well received. Moreover, it would be worth exploring if

concomitantly reducing sensory variety in rice, and thereby palatability, may also decrease rice intake and further improve dietary quality [46]. Although reducing sensory variety has not been specifically examined, research suggests that limiting energy-dense food variety can decrease total energy intake and reduce the pleasure associated with consuming these foods [47, 48]. The recent qualitative study also demonstrated that preference for rice and beans are deeply engrained in the Costa Rican culture; thus we expect that preparation and intake of these staple foods have generally sustained since this study was conducted.

Some limitations of the present analysis should be noted. The study subsample was primarily male because it was selected to represent the population from the geographic area where were the MI cases were drawn. Therefore, the results may not represent female participants to the same extent. Additionally, intake amounts were only queried for the 11 most common ingredients only, which limited the precision of each score and prevented us from assessing the nutritional value of meals prepared with such ingredients. Although the person in charge of food preparation was asked to report the recipe used most of the time, daily food preparation likely varies due to ingredient availability and whether participants added other less common seasonings at the table. While this cross-sectional data provides important insight into the relationship between sensory variety and food intake, other unmeasured confounding variables limit the interpretation of results. Thus, there is a need for randomized controlled interventions as well as longitudinal studies with repeated measures of cooking and eating to better understand the associations between sensory variety and intake.

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This study had several strengths worthy of mention. The study subsample provided a unique opportunity to examine sensory variety within a population-based study. Dietary assessment was conducted with a validated, Costa Rican-specific questionnaire, with detailed questions on usual bean and rice intake. Similarly, the accuracy of reported use of seasonings was likely enhanced because the primary person responsible for food preparation in the household was interviewed. Finally, because beans and rice are the primary components of the Costa Rican diet, examining the effect of seasoning variety within these foods has the potential to substantially impact overall dietary quality in this population, and among other Hispanic cultures with similar staple foods.

In conclusion, this study is particularly relevant in the context of the worldwide obesity epidemic and evidence of nutrition transitions towards decreasing bean intake and increasing consumption of highly processed carbohydrates such as rice in many Latin American countries [14]. Our results provide relevant insight into a technique that can be modified to increase intake of healthful staple foods and potentially decrease intake of those with potential adverse health effects. Similarly, our results would support conducting future studies to test whether simultaneously increasing seasoning variety when preparing beans and reducing seasoning variety when preparing white rice would increase the ratio of beans to rice consumed and further promote metabolic health.

5. ACKNOWLEDGEMENT

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Figure Legends

Figure 1: Mean servings per day of beans and white rice by variety score tertile among Costa Rican adults

Panel (a) shows mean servings per day for beans and panel (b) for white rice across variety score tertiles for each food. Data are presented as means with standard errors. Multivariable linear regression models with Tukey test for multiple comparisons were adjusted for age, sex, area of residence (rural/periurban/urban; except in stratified analysis), case-control status, intake of white rice (for bean intake), income, smoking, physical activity, and total energy intake, and BMI. Variety scores were calculated by summing the number of seasonings (out of 11) reported by each participant; response categories were "no"=0, "sometimes"=1, and "yes"=2, (solid fat, salt, and oil were categorized as 0 for no use and 2 for any use). The maximum possible variety score was 44 for beans (includes seasonings used to both prepare and dress the beans) and 22 for rice recipe. Variety scores for beans were categorized into the following tertiles (T): 0-7 (T1), 8-11 (T2), and 12-32 (T3) ingredients and variety scores for rice were categorized as: 0-8 (T1), 9-10 (T2), and 11-19 (T3) ingredients.

*Significantly different ($p < 0.05$) from reference category (T1)

Figure 2: Mean servings per day of beans and white rice by quality score tertile among Costa Rican adults

Panel (a) shows mean servings per day for beans and panel (b) for white rice across quality score tertiles for each food. Data are presented as means with standard errors. Multivariable linear regression models with Tukey test for multiple comparisons were adjusted for age, sex, area of residence (rural/periurban/urban; except in stratified analysis), case-control status, intake of white rice (for bean intake), income, smoking, physical activity, and total energy intake, and BMI. Quality score (healthfulness of 11 ingredients) was assessed by allocating 2 points for regular use of ingredients rated as 'healthful', 1 point for some use, and 0 points for no use. Ingredients rated as 'unhealthful' were reverse-coded. The maximum possible quality score was 44 for beans (includes seasonings used to both prepare and dress the beans) and 22 for rice. Quality scores for beans were categorized as: 4-12 (T1), 13-19 (T2), and 10-36 (T3) and quality scores for rice were categorized as 1-7 (T1), 8-9 (T2), and 10-16 (T3).

Ϯ Marginal significant difference (p=0.06) from reference category (T1)

Table 1: Socio-demographic and dietary characteristics of 1,025 Costa Rican adults living in rural and urban areas[a-c]

	Overall Population n=1,025	Rural n=455	Urban n=570
Demographic and Lifestyle Factors			
Age (y)	56.9 (10.7)	56.8 (10.8)	57.0 (10.7)
Sex (% female)	26.3	20.9	30.7*
Income ($/month)	507 (464)	429 (384)	567 (509)*
Physical Activity (METs)[d]	32.7 (18.2)	35.6 (21.4)	30.4 (14.8)*
Current smoker (%)	35.7	35.8	35.6
BMI (kg/m^2)	25.8 (4.0)	25.6 (4.1)	26.0 (4.0)
Dietary Factors			
Total energy intake (kilocalories)	2537 (808)	2654 (840)	2443 (769)*
White rice (servings/day)	2.0 (0.78)	2.1 (0.66)	1.8 (0.83)*
Beans (servings/day)	1.4 (0.98)	1.6 (0.96)	1.2 (0.96)*
Variety score[b]			
Beans	10.0 (5.1)	9.7 (4.9)	10.2 (5.2)
White rice	9.8 (2.7)	10.2 (2.6)	9.6 (2.8)*
Quality score[c]			
Beans	16.4 (6.6)	15.8 (6.2)	16.8 (6.9)*

White rice	8.6 (2.7)	8.6 (2.6)	8.7 (2.7)
Beans Ingredient Use (%)			
Salt	92.8	94.7	91.2*
Garlic	77.7	80.0	75.9
Cilantro	57.1	56.0	58.1
Onion	55.2	51.8	57.9*
Oregano	34.3	29.7	37.9*
Celery	32.9	30.2	35.2
Sweet Pepper	32.3	28.6	35.2*
Oil	27.1	22.6	30.7*
Solid Fat	23.8	28.1	20.4*
English Sauce	11.5	10.4	12.3
Bouillon	9.9	11.2	8.8
Rice Ingredient Use (%)			
Salt	96.6	98.5	95.1*
Onion	87.4	89.2	85.9
Sweet Pepper	78.7	80.2	77.5
Oil	58.2	50.6	64.2*
Garlic	57.2	56.0	58.2
Solid fat	38.9	47.9	31.8*
Cilantro	25.6	35.8	24.6*
Celery	12.6	14.1	11.4
Bouillon	8.1	9.2	7.2

Carrot	6.6	8.8	4.9*
Achiote (Annato)	3.2	4.0	2.6

[a] Continuous variables are presented as means and standard deviations and categorical variables are presented as %

*p<0.05 between area of residence

[b] The frequency of use for 11 possible ingredients used to season beans and rice. For beans, seasoning ingredients were added from a two-step process that involves both cooking and dressing the beans. The maximum possible score variety score was 44 (maximum observed score=32) for bean recipes and 22 (maximum observed score=19) for rice.

[c] The quality or healthfulness of the ingredients used to season beans and rice for 11 possible ingredients. The maximum possible quality score was 44 (maximum observed score=32) for bean recipes and 22 (maximum observed score=16) for rice.

[d] Metabolic Equivalents (METs)

Table 2: Socio-demographic and dietary characteristics across black beans and white rice variety and quality score tertiles among 1,025 Costa Rican adults[a-c]

	Quality				Variety			
	Beans		**Rice**		**Beans**		**Rice**	
	T1	**T3**	**T1**	**T3**	**T1**	**T3**	**T1**	**T3**
Demographic and Lifestyle Factors								
Age (y)	57.3 (0.57)	56.9 (0.60)	56.2 (0.57)	57.5 (0.56)	56.7 (0.64)	55.7 (0.55)	56.5 (0.59)	57.4 (0.58)
Sex (% female)	30.1	23.0	26.2	24.9	29.5	23.8	26.9	26.6
Area (% urban)	53.7	61.6*	53.6	56.6	52.5	61.0*	63.6	50.7*
Income ($/month)	473 (25.5)	581 (26.3)*	423 (25.1)	548 (24.2)*	459 (29.1)	554 (24.4)*	563 (26.0)	490 (25.9)
Physical Activity (METs)[d]	34.0 (0.95)	30.6 (1.00)*	34.9 (0.98)	32.0 (0.96)	33.6 (1.09)	30.8 (0.94)	32.1 (0.99)	33.1 (0.99)
Current smoker (%)	33.3	34.0	43.9	28.3*	34.4	37.4	41.2	31.4*
BMI (kg/m^2)	26.0 (0.22)	25.7 (0.23)	25.4 (0.22)	26.2 (0.21)*	26.1 (0.24)	25.9 (0.21)	25.5 (0.22)	26.2 (0.22)
Dietary Factors								

Total energy intake (kilocalories)	2412 (42.5)	2644 (44.9)*	2602 (43.3)	2538 (42.3)	2418 (48.0)	2650 (41.4)*	2510 (44.2)	2587 (43.8)
White rice (servings/day)	2.00 (0.04)	1.93 (0.04)	2.03 (0.04)	1.92 (0.04)	2.05 (0.05)	1.89 (0.04)*	1.88 (0.04)	2.01 (0.04)
Beans (servings/day)	1.32 (0.05)	1.42 (0.05)	1.51 (0.05)	1.29 (0.05)	1.33 (0.05)	1.36 (0.05)	1.34 (0.05)	1.46 (0.05)
Variety score[b]								
Beans	5.30 (0.17)	14.8 (0.18)*	9.01 (0.27)	10.9 (0.26)*	4.17 (0.15)	15.2 (0.13)*	8.69 (0.27)	11.3 (0.27)*
White rice	9.39 (0.14)	10.2 (0.15) *	8.24 (0.12)	11.7 (0.12)*	9.13 (0.15)	10.4 (0.13)*	6.96 (0.08)	12.7 (0.07)*
Quality score[c]								
Beans	9.65 (0.13)	24.4 (0.14)*	14.7 (0.35)	17.8 (0.34)*	9.70 (0.24)	22.7 (0.21)*	14.9 (0.36)	17.5 (0.36)*
White rice	8.13 (0.14)	9.25 (0.15)*	5.73 (0.06)	11.4 (0.06)*	8.12 (0.16)	9.10 (0.14)*	6.65 (0.12)	10.5 (0.12)*
Ingredient Use (%)								
Salt	85.7	97.8*	95.7	97.0	82.7	96.8*	93.1	98.5*
Garlic	62.9	89.6*	27.9	87.2*	52.3	92.3*	23.3	79.7*
Cilantro	30.9	78.3*	14.0	51.9*	15.1	85.6*	2.4	69.3*
Onion	11.5	95.0*	76.9	97.0*	10.8	92.0*	69.6	97.9*

Oregano	25.0	42.8*	--	--	16.6	47.9*	--	--
Celery	13.2	45.9*	1.4	28.1*	6.47	55.1*	0.60	34.5*
Sweet Pepper	10.4	53.1*	70.9	86.1*	2.52	61.0*	54.3	93.2*
Oil	2.3	66.0*	17.4	88.0*	4.68	50.5*	49.9	63.1*
Solid Fat	6.7	34.3*	77.2	10.9*	5.76	36.6*	42.4	36.0*
English Sauce	2.8	21.7*	--	--	0.36	26.7*	--	--
Bouillon	6.2	9.1*	10.8	6.3	1.44	17.7*	3.28	18.6*
Carrot	--	--	3.1	10.9*	--	--	1.19	15.0*
Achiote (annatto)	--	--	2.3	4.6	--	--	0.3	6.2*

[a] Continuous variables are presented as means and standard deviations and categorical variables are presented as %

*$p<0.05$ between tertile 1 (T1) and tertile 3 (T3) of bean or rice quality score or between T1 and T3 of bean or rice variety score

[b] The frequency of use for 11 possible ingredients used to season beans and rice. For beans, seasoning ingredients were added from a two-step process that involves both cooking and dressing the beans. The maximum possible score variety score was 44 (maximum observed score=32) for bean recipes and 22 (maximum observed score=19) for rice.
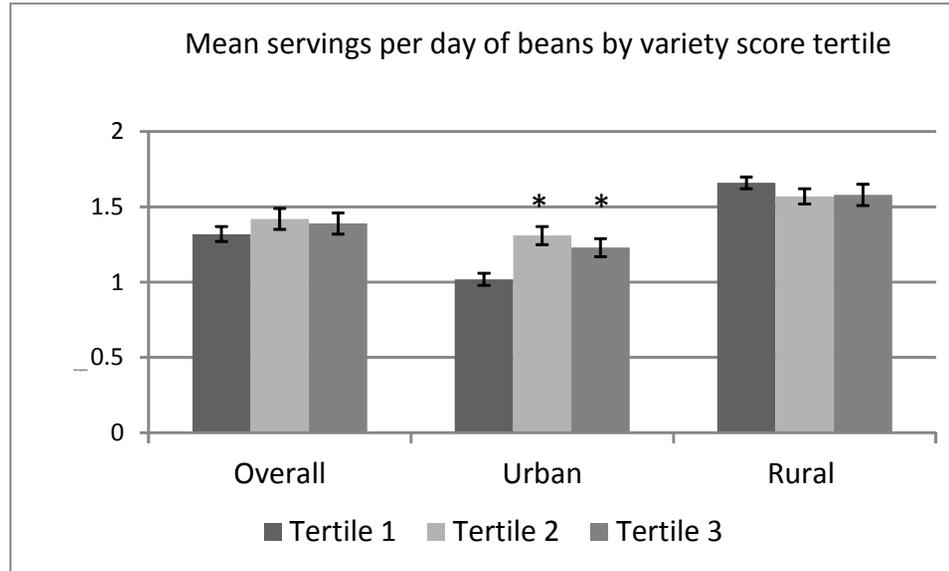
[c] The quality or healthfulness of the ingredients used to season beans and rice for 11 possible ingredients. The maximum possible quality score was 44 (maximum observed score=32) for bean recipes and 22 (maximum observed score=16) for rice.
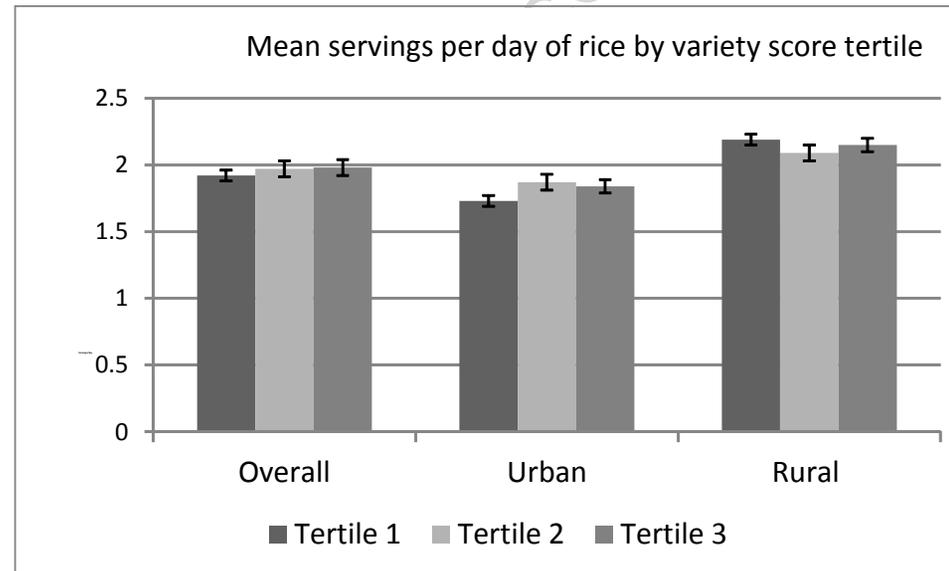
[d] Metabolic Equivalents (METs)

Figure 1: Mean servings per day of beans and white rice by variety score tertile among Costa Rican adults

A)

B)

Figure 2: Mean servings per day of beans and white rice by quality score tertile among Costa Rican adults

A)

B)

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